Relation between length of wire and elevation of kite.

Date.	Number of observations.	Average length of wire.	Average angular elevation.	Average elevation of kite.
		Feet.	° ′	*Feet.*
June 27	12	1081	38 0	637
July 1	34	3547	33 30	1869
July 2	16	2722	38 36	1565
July 3	18	3979	44 42	2635
July 6	22	4728	42 30	2865
June 27–July 6	102			
Means		3211	39 28	1914

The average ratio of elevation to length of wire for all heights is a trifle less than 0.60. This value is based on 102 observations. The ratio varied but little throughout the experiments. The average ratio for 18 elevations exceeding 3000 was 0.59. The average angular elevation of the kite was 39° 28′ for all observations, and 38° 30′ for the 18 elevations exceeding 3000 feet.

THUNDERSTORMS AT LINCOLN, NEBR.

By JAMES H. SPENCER, Observer, United States Weather Bureau, dated Lincoln, Nebr., December 19, 1903.

The following extracts, revised to December 1, 1903, are from an article on Thunderstorms, by Mr. James H. Spencer, Observer, United States Weather Bureau, Lincoln, Nebr., which was officially published in the Proceedings of the Nebraska Academy of Sciences, Vol. VII:

Thunderstorms have more than usual interest to the residents of most of the States lying between the Mississippi River and the eastern slope of the Rocky Mountains. In this great region they probably supply not less than two-thirds of the precipitation during the summer months, and crop failure or success depends very largely upon their frequency, extent, and the amount of rainfall.

* * * * * * *

Careful records of thunderstorms have been kept for Lincoln, Nebr., since April 1, 1896, and although a longer record is necessary to establish trustworthy averages for comparison, the statistics deduced from the record for the eight years ending November 30, 1903, particularly for the crop seasons will be found of interest.

The total number of thunderstorms passing over the station[1] for the entire period was 302, or an average of 38 for each year. About 50 per cent occurred during the night (from 7:00 p. m. to 7:00 a. m.) and about 70 per cent. between noon and midnight. Nearly 90 per cent. were recorded as coming from some westerly direction. Two hundred and forty-four of the 302 thunderstorms, or 81 per cent. of the entire number, occurred during the forty months of the eight crop seasons—from April to August, inclusive—the time of year in Nebraska when moisture is most needed. The distribution of the storms by years, and for the five months of the crop season, the total rainfall for each month, and the approximate amount which fell during thunderstorms, are given in the folling table:

Thunderstorms at Lincoln, Nebr.

Year and month.	Number of thunderstorms.	Precipitation (in inches).	
		Total for month.	Total during thunderstorms.
1896.			
April	3	4.57	2.62
May	8	10.11	4.20
June	5	3.05	2.43
July	4	5.63	3.92
August	3	3.39	1.77
Total for crop season	23	26.75	14.94
1897.			
April	3	6.15	2.96
May	3	2.22	1.32
June	3	2.17	0.63
July	0	2.54	0.00
August	5	2.69	1.82
Total for crop season	14	15.77	6.73
1898.			
April	3	3.88	0.22
May	4	4.33	2.90
June	3	3.99	1,26
July	3	3.93	3.69
August	3	3.45	2.68
Total for crop season	16	19.58	10.75
1899.			
April	4	1.49	0.87
May	12	2.29	1.57
June	11	8.39	8.35
July	4	1.47	1.15
August	6	2.66	1.74
Total for crop season	37	16.30	13.68
1900.			
April	7	4.33	1.44
May	7	4.50	4.14
June	11	2.50	2.44
July	9	6.66	5.78
August	7	9.07	8.91
Total for crop season	41	27.06	22.71
1901.			
April	1	1.46	0.53
May	3	1.96	1.69
June	9	1.42	1.24
July	5	2.94	2.88
August	7	1.02	0.78
Total for crop season	25	8.80	7.12
1902.			
April	3	0.67	0.11
May	9	3.65	1.34
June	11	8.83	7.20
July	13	11.35	10.21
August	7	4.35	3.87
Total for crop season	43	28.85	22.73
1903.			
April	3	3.50	2.73
May	12	10.72	7.57
June	7	2.60	1.52
July	11	3.07	3.07
August	12	6.45	5.93
Total for crop season	45	26.43	20.82
Total for 8 crop seasons	244	169.54	119.48
Average for each crop season	30.5	21.19	14.94

Thus it is found that about 70 per cent. of the total amount of rainfall for the crop season is due to the passage of thunderstorms, and that the percentage of rainfall from thunderstorms during the most critical crop months in Nebraska—July and August—is still greater. The average rainfall for each crop season, excluding that due to thunderstorms, was only 6.25 inches.

* * * * * * *

The maximum wind velocity for the eight years, and the highest ever recorded for five minutes at Lincoln, was 80 miles per hour, occurring in the thunderstorm of May 12, 1896. No very great damage resulted from this storm.

The year 1900 furnished an unusual number of excessive wind and precipitation records for Lincoln. Both the number of thunderstorms and the rainfall were considerably above the normal. During the thunderstorm of July 15 over 3 inches of water fell, more than two-thirds of which occurred in one hour. A month later, on August 16 and 17, 4.27 inches of water fell in twenty-four hours, an amount more than 1 inch in excess of the normal rainfall for that month. During the thunderstorm of August 23, 0.61 of an inch was recorded in five minutes. At this rate our entire annual precipitation would occur in less than four hours. During the storm of August 21 occurred the highest wind velocity for the year, averaging 78 miles per hour for five minutes, but for one minute exceeding 100 miles per hour. Hundreds of trees were blown down or had large limbs blown off and the roofs of a number of buildings were badly damaged.

[1] The instructions for Weather Bureau observers require that thunderstorms be recorded when thunder is heard at the station, without reference to any other feature.—ED.

The summer of 1902 also gave some very interesting thunderstorm data for Lincoln. Tho total rainfall for June and July was 20.18 inches, or within 6.58 inches of the yearly normal; of this amount 86 per cent. occurred during thunderstorms. The July rainfall was 11.35 inches, or three times the normal amount. It is interesting to note that of this amount only 0.89 of an inch occurred during the twelve hours ending at 8 p. m.

The thunderstorm of May 26, 1903, was the most destructive on record at the station. A maximum wind velocity of 76 miles an hour was recorded. About one mile southwest of the office the storm appeared to be even more severe, and several large buildings were damaged by the wind to the extent of nearly $100,000.

RECENT STUDIES ON THE SOLAR CONSTANT OF RADIATION.

By C. G. ABBOT. Reprinted from Smithsonian Miscellaneous Collections (Quarterly Issue), volume 45. Published December 9, 1903. (Revised by the author.)

INTRODUCTION.

Within the last two years the observations of the Smithsonian Astrophysical Observatory under the direction of the

Secretary, Mr. Langley, have been largely for the purpose of measuring the total solar radiation, its distribution in the spectrum, and the losses which it suffers by absorption in the solar and terrestial gaseous envelopes. In the experimental work and reduction of observations Mr. Langley has been aided by the writer, but chiefly by F. E. Fowle, jr., whose able handling of the work I wish particularly to acknowledge and commend. Preliminary notices of this investigation have appeared in the Smithsonian Report for 1902, and in an article by the Secretary in the Astrophysical Journal for March, 1903, to which sources the reader is referred for additional information in relation to the methods of study. In the present paper will be found a summary of the results thus far reached.

ATMOSPHERIC ABSORPTION.

It is well known that the effectiveness of the solar and terrestial gaseous envelopes to intercept by reflection or absorption and thus diminish the intensity of the solar radiations at the earth's surface, varies greatly for rays of different wave-lengths. It is customary, speaking of the matter in ready though not strictly accurate terms, to combine these two effects of reflection and absorption under the single head of absorption, but to distinguish two kinds of absorption, namely, general and selective, of which the latter includes such sudden alterations of transmission as are seen in the Fraunhofer lines, while the former denotes merely a general weakening of the radiation extending over wide ranges of wave length. Using this nomenclature, it appears to be the general absorption of the solar and terrestial envelopes which chiefly affects the amount of solar radiation at the earth's surface, although the selective absorption of water vapor in the atmosphere is also both very effective and very variable.[1]

The procedure employed here to determine the general absorption of the air consists chiefly in making bolographs—that is, automatic energy spectra—of the solar radiation as often as possible throughout days of uniform and excellent sky without alteration of the sensitiveness of the apparatus. Such energy spectra are altered in appearance from one to another by the varying absorption of the different thicknesses of air, so that a little after noon the height of the curve is found to be a maximum for all wave lengths, and the height falls off as the sun declines in altitude, slowly in the infra-red region of the spectrum, but more and more rapidly as we examine further and further toward the violet, or still more rapidly if we note the greater atmospheric absorption bands due to water vapor.

It is assumed that the atmospheric transmission for a very narrow portion[2] of spectrum may be expressed by the relation—

$$e = e_0\, a^{m\frac{\beta}{\beta_0}} \tag{1}$$

where e and e_0 are the intensities of light of this wave length at the earth's surface and outside the atmosphere respectively; a the fraction transmitted by the atmosphere for zenith sun; m the air mass, or ratio of the length of the transmitting column of air to that for zenith sun; β and β_0 the observed and standard barometer readings respectively. Upon the bolograph the height d corresponding to any given wave length is directly proportional to the amount of energy of that wave length. Accordingly we may introduce a factor k constant for the single wave length in question

$$d = ke = ke_0 a^{m\frac{\beta}{\beta_0}} \tag{2}$$

and hence,

$$\log d = m\frac{\beta}{\beta_0} \log a + \log\,(ke_0). \tag{3}$$

As the last term of equation (3) is to be supposed constant during the day's observations, the expression is in the form of the equation of a straight line, and if the logarithms of the deflections at the given wave-length on the successive bolographs be plotted as ordinates with the quantities ($m\,\beta/\beta_0$) as abscissæ, the several points so determined should fall on a straight line of which the tangent of the inclination is the logarithm of the transmission coefficient (a) for the given wave length.

Mr. Langley has stated that the attempted measurements of the solar constant from a station near sea level like Washington are subject to great uncertainty from the necessity of the very large and doubtful extrapolation for atmospheric absorption. Without in the least questioning this, and while calling special attention to the great interest which would attach to a repetition of the experiments at high altitudes, I incline to the belief that the closeness with which the plotted points, determined as above described, lie upon a straight line for wide ranges of air mass is a reasonably sure criterion of the accuracy of the extrapolation. In order to give an impression of the weight which should be assigned to the solar constant values shortly to be given, I call attention to fig. 1, which contains the plots for deducing atmospheric transmission at several wave lengths for two days, March 25, 1903, and March 26, 1903, observations for the two days being represented by circles and crosses respectively. The tangent of the angle of inclination of the plotted lines is the logarithm of the coefficient of transparency of the atmosphere for vertical transmission of a ray of the given wave length. Plots I and II represent a wave length of 1.027 μ; III and IV, 0.656 μ; V and VI, 0.468 μ; and VII and VIII, 0.395 μ. In connection with this branch of the subject, it is well to remark what the experience of meteorologists generally no doubt confirms, that the afternoon hours are found far more uniform as to transparency of the air than the morning hours, so that the observations of atmos-

[1] K. Ångström has, however, attributed much importance to the absorption of carbonic acid gas, implying by his computation that not less than 61 per cent of the solar radiation which reaches the outer layers of the earth's atmosphere is cut off by the absorption of this gas in a vertical transmission through the air. (See Annalen der Chemie und Physik, vol. 39, pp. 309-311, 1890.) He locates the absorption of this gas principally in the bands at 2.6μ and 4.3μ: so that, as he says, its effect is not allowed for in the procedure for obtaining the value of the solar constant of radiation adopted by Mr. Langley in his research on Mount Whitney, and which is essentially that employed here. Ångström, while using the same method in part, added a second term amounting to more than half the whole in his computation, solely referring to the absorption of carbonic acid gas, and thus he obtained his oft-quoted result for the solar constant of radiation of 4.0 calories per square centimeter per minute. For several reasons I am inclined to think Ångström has greatly overestimated the importance of this carbonic acid absorption term: First, as he shows, the selective absorption of carbonic acid gas is almost wholly for wave lengths greater than 2.5μ and principally in two bands between wave lengths 2.5μ and 2.85μ and between 4.20μ and 4.50μ, respectively, where the total amount of the solar radiation is apparently less than one per cent of the whole, as determined not only from the appearance of the observed bolographic solar spectrum energy curve itself, but from a consideration of the probable temperature of the sun and the distribution of energy in the spectra of bodies at high temperatures. As a very evidently too great estimate of the energy in these wave-length regions, it may be seen that if the radiation outside the atmosphere (see fig. 3) was of the same intensity throughout these bands as at 2.1μ, the area they would include would be only about one-fiftieth the total area under the curves of fig. 3. It is of course very improbable that the height of the curve at 4.3μ is nearly as great as at 2.1μ. Thus it would appear that the selective absorption of this gas for direct solar radiation is almost negligible. Second, if carbonic acid exercised a general absorption through the more intense parts of the solar spectrum, it is not apparent why such a general absorption is not included and allowed for in the coefficients of absorption here determined. Third, values of the solar constant computed here for the same day, but from observations made through very different thicknesses of air, are found to agree excellently, which appears to confirm the accuracy of the method of determining the atmospheric absorption which is here employed.

After the first publication of this paper my attention was drawn to Ångström's later article on this subject. (Ann. d. Physik, 4, 3, 720, 190.) I am glad to find that he now attaches much less importance to the absorption by CO_2 of solar radiation, and, in consequence, that he now discountenances the value 4.0 cal., so often quoted for the solar constant.

[2] In our practise less than the width between the D lines.

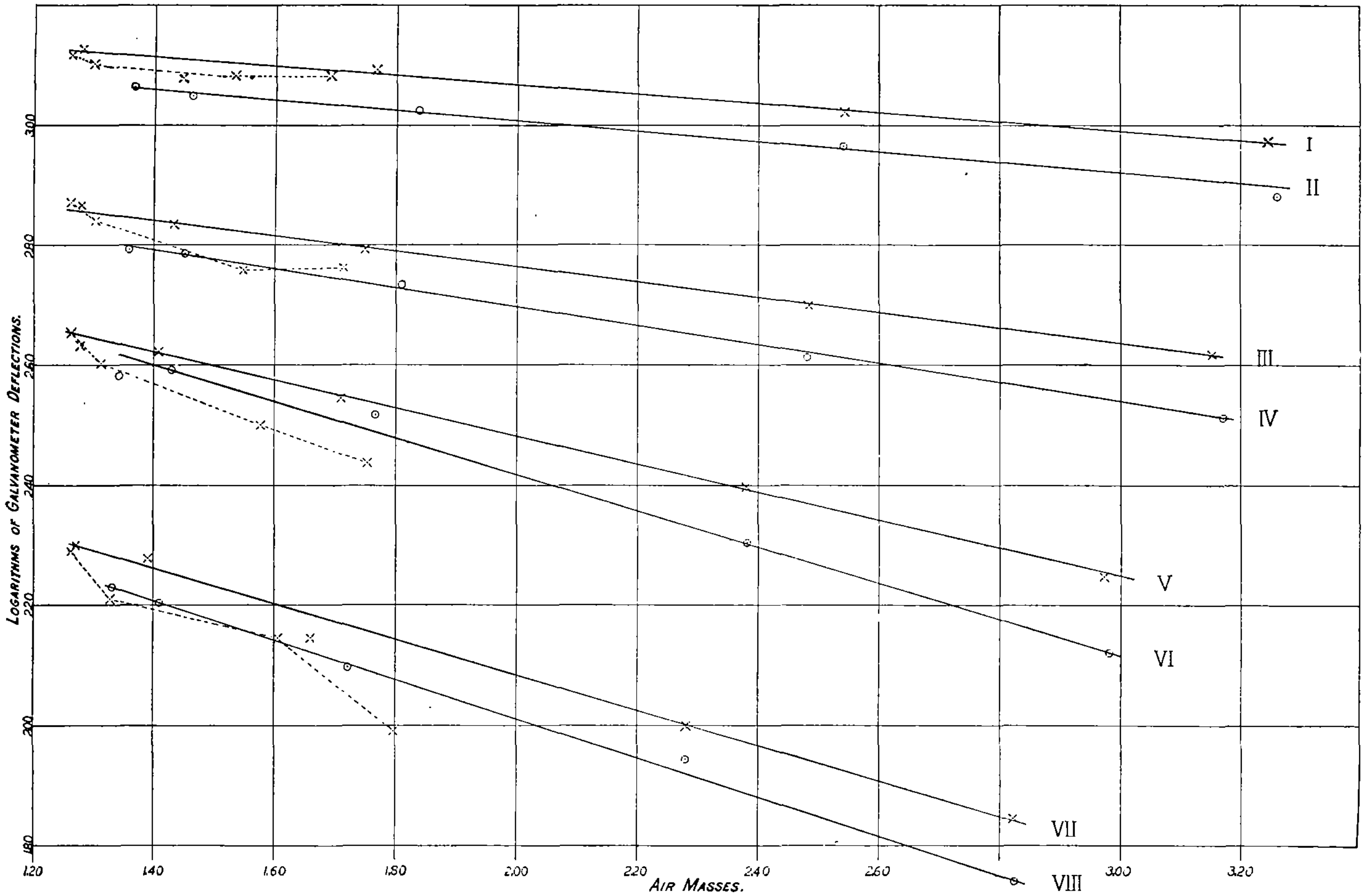

FIG. 1.—Transparency of the atmosphere from bolographic observations.

TABLE 1.—*Coefficients of atmospheric transmission for radiation from zenith sun.*

Wave-length.	0.40 μ.	0.45 μ.	0.50 μ.	0.60 μ.	0.70 μ.	0.80 μ.	0.90 μ.	1.00 μ.	1.20 μ.	1.60 μ.	2.00 μ.
Date.	Transmission coefficients for unit air mass.										
October 25, 1901	....	....	0.81	0.82	0.89	0.94	....	0.95	0.96	0.95	....
November 2, 1901	....	....	0.80	....	0.87	0.92	....	0.94	0.95	0.94	....
March 21, 1902	....	....	0.83	0.80	0.84	....	....	....	....	0.87	....
May 8, 1902	....	....	0.89	0.77	0.90	0.94	....	0.95	0.94	0.91	....
September 11, 1902	....	....	0.80	0.78	0.87	0.89	0.92	0.92	0.94	0.93	....
October 9, 1902	....	....	0.70	0.78	0.84	0.87	0.89	0.90	0.91	0.93	....
October 15, 1902	....	....	0.73	0.78	0.86	0.89	0.90	0.91	0.93	0.96	0.94
October 16, 1902	....	....	0.50	0.58	0.79	0.82	....	0.86	0.90	0.91	....
October 22, 1902	....	....	0.84	0.82	0.88	0.91	0.93	0.94	0.94	0.95	....
November 15, 1902	....	....	0.75	0.79	0.83	0.89	0.91	0.92	0.93	0.95	0.96
February 19, 1903	0.67	0.64	0.66	0.72	0.76	0.80	0.83	0.85	0.86	0.90	0.92
February 25, 1903	0.48	0.60	0.66	0.68	0.74	0.83	0.88	0.90	0.93	0.93	0.92
March 3, 1903	0.40	0.48	0.66	0.73	0.79	0.84	0.87	0.89	0.92	0.96	0.96
March 25, 1903	0.47	0.50	0.57	0.66	0.72	0.76	0.79	0.81	0.84	0.88	0.89
March 26, 1903	0.52	0.58	0.62	0.68	0.77	0.80	0.81	0.83	0.85	0.89	0.90
April 17, 1903	0.55	0.60	0.69	0.77	0.80	0.82	0.87	0.90	0.94	0.97	0.97
April 28, 1903	0.39	0.52	0.56	0.64	0.71	0.74	0.76	0.78	0.82	0.88	0.89
April 29, 1903	0.46	0.49	0.56	0.66	0.72	0.76	0.77	0.80	0.83	0.88	0.90
July 7, 1903	0.42	0.60	0.66	0.69	0.77	0.82	0.85	0.86	0.88	0.89	0.86
General mean	0.484	0.557	0.700	0.730	0.808	0.847	0.856	0.884	0.903	0.920	0.919
Mean of 1901-2	....	....	0.765	0.769	0.857	0.897	0.910	0.921	0.933	0.930	0.950
Mean of 1903	0.484	0.557	0.627	0.692	0.753	0.797	0.825	0.847	0.874	0.909	0.912
Percentage difference between mean of 1903 and that of 1901-2	....	....	20%	10%	13%	12%	10%	8.4%	6.5%	2.3%	4.1%

These wave lengths were selected to avoid large terrestial absorption bands and the coefficients present the effect of the general absorption only.

pheric transmission for use in computing values of the solar constant have been obtained chiefly in the afternoon. Forenoon observations are distinguished in fig. 1 by being connected by dotted lines.

In order to fix our ideas as to the magnitude and the variability of the absorption of the earth's atmosphere, the preceding Table 1, showing the percentage of transmission at numerous different wave lengths for the days indicated, is given. The computations upon which the table is based were made at wave lengths specially selected to avoid large terrestrial absorption bands, and thus the table gives values of the general absorption only. A few reductions have been made to determine the selective absorption within the numerous atmospheric bands of water vapor and oxygen, but while their discussion has gone far enough to show that equation (1) apparently holds good in these bands, the results are not yet far enough advanced to be included in the tables. As another criterion of the accuracy of the method of extrapolation, and in accord with what has just been said, it is found that in computations of the form of the solar energy curve outside the atmosphere, the employment of the observed values of transmission within the water-vapor bands would practically fill up these bands: However, in determining the solar constant they have been smoothed over and the general transmission constants corresponding to smoothed curves are employed in the computation.

The days included in Table 1 were all nearly cloudless, and thus the results represent the transmission of the atmosphere in better than average conditions. In order to bring out clearly what seems to be a marked decrease in the transparency of the air for the present calendar year, the means of the general transmission coefficients have been taken for the observations of 1901–2, and for those of 1903 separately. There is an average difference of 10 per cent in favor of the earlier years, and this can not, so far as I know, be accounted for in any other way than by recognizing an actual decrease in the transparency of the air, beginning somewhere between November 15, 1902, and February 19, 1903. It might be urged that the change is perhaps an annual one, as most of the observations of 1901–2 are in the autumn, and those of 1903 in the spring. But, in contradiction to this view, we find the observations of March and May, 1902, generally above the mean of that year, so that I incline to think the change rather extraordinary than annual in character. Such a change would imply a corresponding reduction in the amount of direct solar radiation received at the earth's surface, and if general over a wide area would seem to be likely to occasion some alteration of climate. Recent actinometric observations reported by several observers in this country and in Europe[3] seem to strengthen the probability that the change in transparency of the air is widespread, for their measures of solar radiation at the earth's surface have been appreciably lower of late than for the same months of former years. Several writers have suggested the possibility of the wide dissemination of fine dust clouds from the volcanic eruptions of 1902, in explanation of the lower values. It will be noted from Table 1 that the differences between the means of 1901–2 and 1903 are largest for short wave lengths and diminish nearly uniformly toward the infrared as far as a wave length of 1.2μ, which would probably be in harmony with this hypothesis; for such small dust particles might be expected to scatter and absorb the shorter wave lengths most, not being large enough to act like an opaque screen diminishing all wave lengths proportionally.

COMPUTATIONS OF THE SOLAR CONSTANT OF RADIATION.

The coefficients of general atmospheric transmission resting upon measures at 24 different wave lengths from 0.37μ to 2.3μ on series of bolographic curves have been employed at the Astrophysical Observatory in connection with bolographs and actinometric data to compute the solar constant of radiation outside the atmosphere. Referring to fig. 2 the area included underneath a spectral energy curve is directly proportional to the total radiation absorbed by the bolometer over the range of wave lengths included in the curve. But this area is not strictly proportional to the total solar radiation at the earth's surface, as determined by actinometer observations, for the reason that the radiation has been unequally reduced at different wave lengths by losses at the siderostat mirror, and within the spectroscope, and also by selective absorption at the bolometer itself. It is necessary to correct the curve so that it shall as accurately as possible represent the distribution of energy in the solar beam prior to these losses. Inasmuch as the coefficient of total absorption of the lampblacked bolometer strip is upward of 95 per cent, it is believed that no considerable error is admitted by neglecting its differences of absorption for different wave lengths, and no correction is applied for these. The relative absorption of the spectroscope for different wave lengths is frequently determined, and that of the siderostat mirror still more frequently; for in both these optical parts of the apparatus there is rapid deterioration of the reflecting power of the silvered glass surfaces. At present this indeed forms one of the main difficulties and sources of error of the investigation, for a whole day of observing and several days of computing are required for each determination of the absorption of the apparatus, which would be determined once and for all if constant reflecting surfaces could be employed.

[3] See note by H. H. Kimball, Monthly Weather Review, May, 1903.

By means of the coefficients of absorption of the apparatus thus determined, the area included under the bolographic curve is to be increased so that the total corrected area is then proportional to the solar radiation at the earth's surface as measured with the actinometer or pyrheliometer. Then by the aid of formula 1, given above, and employing the transmission coefficients determined from the series of bolographs of the day, the area is again corrected till it becomes proportional to the total radiation outside the atmosphere. The ratio of the area as corrected for atmospheric absorption to the area corrected only for instrumental absorption is the factor by which the reduced pyrheliometer reading is to be multiplied to give the "solar constant" so called.[4]

It is evident that these "solar constant" values depend directly upon the pyrheliometer or actinometer readings for their accuracy, so that these instruments become here of major importance. In the work thus far a mercury pyrheliometer has been used as the primary standard, and the daily observations have been taken sometimes with it, sometimes with a Crova alcohol actinometer (specially constructed for this Institution under M. Crova's valued supervision), and sometimes with both instruments simultaneously. It has been shown by repeated comparisons of the two instruments and by comparisons of the pyrheliometer with another type that they give proportional results under widely differing conditions of wind and temperature, so that I have no question as to the relative accuracy within 2 per cent of the actinometric data employed in computing values of the "solar constant." There is, on the other hand, room for question as to the absolute magnitudes of the values given, for these depend on the constants and the theory of the mercury pyrheliometer. Steps are being taken to get further checks on this matter, and in a later publication it is expected to recompute the data in accord with later information. For the present, then, the values in the following Table 2 are to be held as relatively accurate and consistent among themselves, but subject later to correction by a common multiplying factor.

The bolographs used in the computations extend from wave lengths 0.37μ to wave length 2.5μ with the exception of those of October, 1902, which reached only to a wave length of 0.48μ in the violet. For these latter bolographs a correction of about 12 per cent was applied, founded on the later work, and thus the results for October, 1902, are entitled to slightly less weight on this account. All the areas have been extrapolated for the radiations lying outside at both ends of the region 0.37μ to 2.5μ, but the corrections so applied amount to less than one per cent altogether. Their magnitude was determined by an inspection of the rate of decrease of successive corrected areas approaching the limits of the curves, and the corrections were checked both by computing according to Wien's formula the probable form of the solar energy curve corresponding to the assumed solar temperature of 6000°, and by examination of the normal energy curves outside the atmosphere as computed from bolographs and given in fig. 3.

I have thought it worth while to give, in addition to the

[4] In computing these corrected areas the bolograph is divided into 24 regions, each of which is separately reduced by applying the mean coefficients of atmospheric and instrumental transmission within the region in question. As already stated, the water vapor absorption bands are smoothed over and corrected for atmospheric absorption by aid of general transmission coefficients.

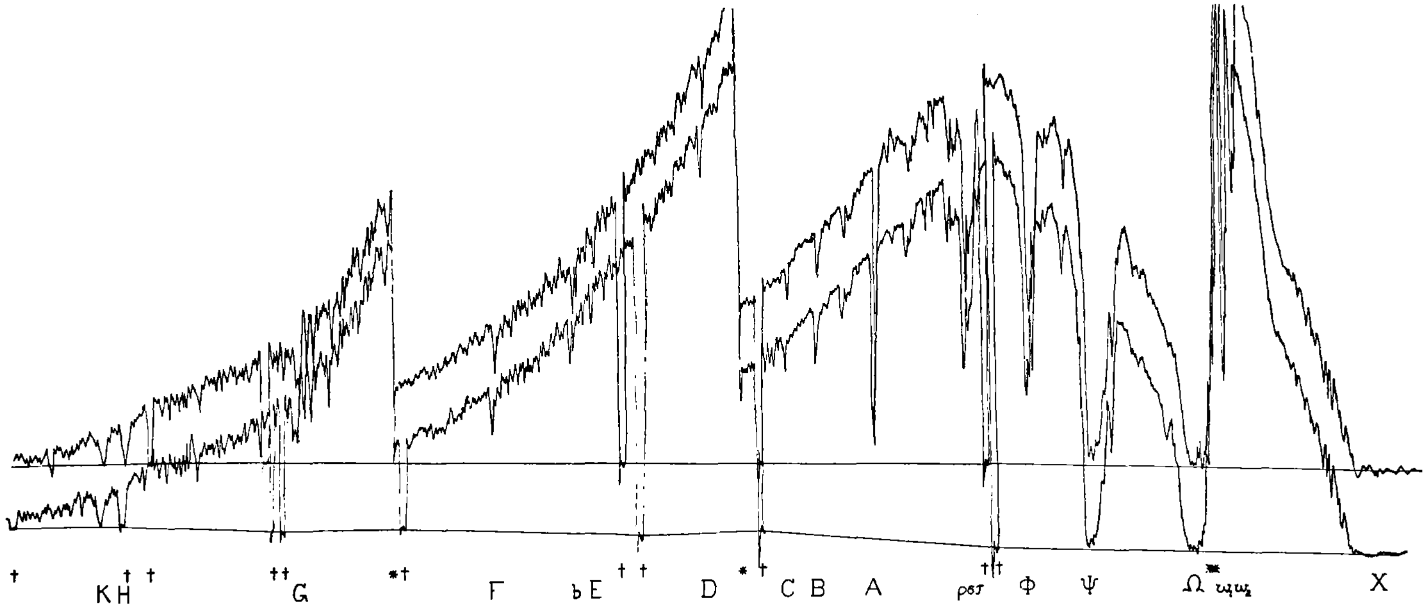

FIG. 2.—Bolographic energy curves of the solar spectrum of a 60° glass prism. Observations of April 17, 1903.
(† Beam cut off by shutter to give position of zero line. * Slit diminished by interposing grill diaphragms. ** Slit increased by removing grill diaphragms.)

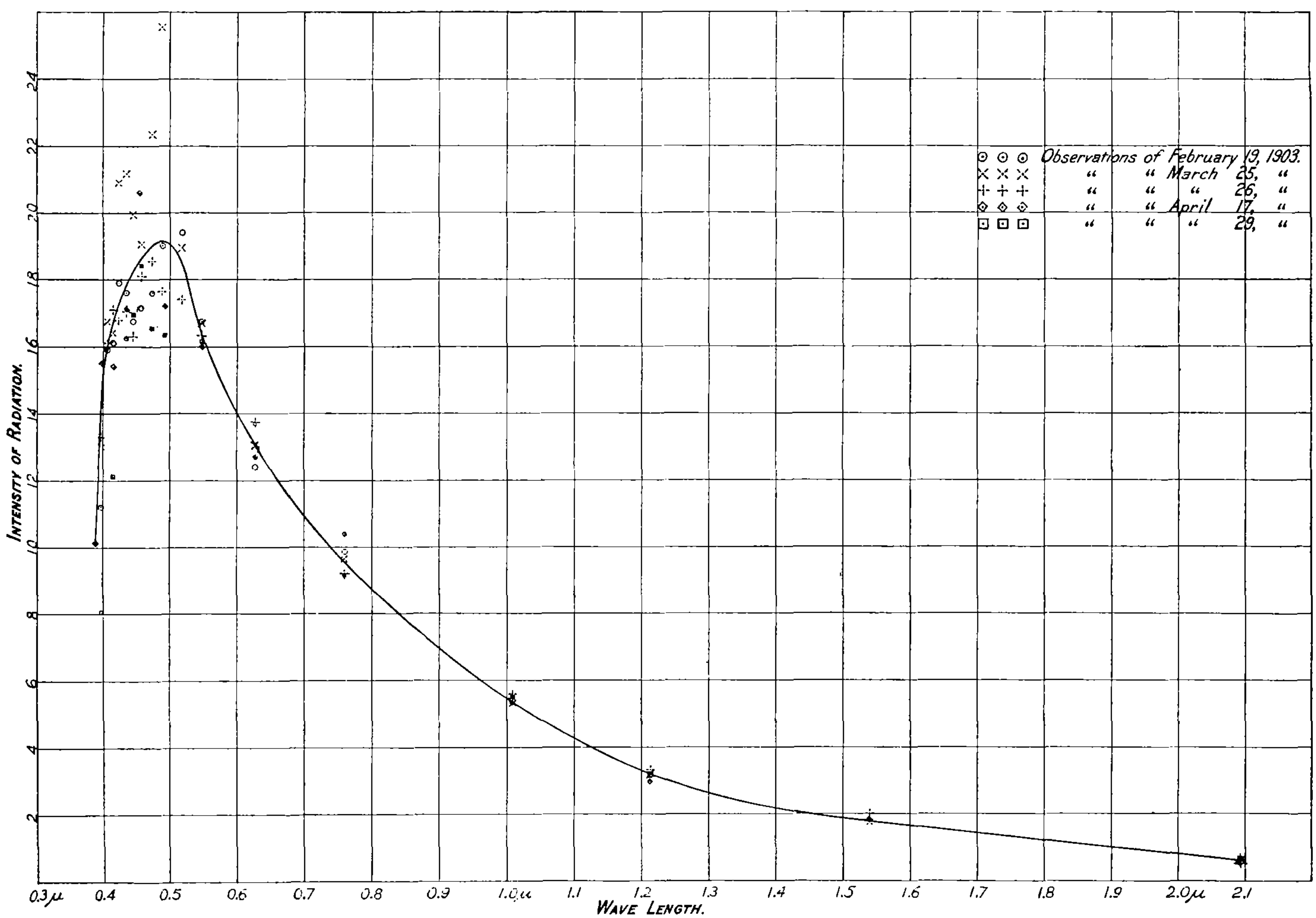

FIG. 3.—Distribution of radiation in the normal solar spectrum outside the earth's atmosphere.

TABLE 2.—*Values of the solar constant of radiation. From bolographic studies.*

Date.	Hour angle. West.	Air mass.	Calories per square centimeter per minute. At the earth's surface.	Calories per square centimeter per minute. Outside the atmosphere.	Solar constant; for mean distance of the sun.
1902.	h. m.		Calories.	Calories.	
October 9	0 6	1.425	1.42	2.20	2.19
October 15	1 31	1.624	1.44	2.21	2.19
October 22	3 01	2.415	1.30	2.18	2.16
1903.					
February 19	1 01	1.642	1.35	2.34	2.28
February 19	2 22	2.003	1.20	2.31	2.25
March 3	0 59	1.429	1.34	2.31	2.26
March 25	2 01	1.454	1.19	2.29	2.27
March 26	1 57	1.438	1.16	2.11	2.10
March 26	2 59	1.754	1.05	2.09	2.07
April 17	2 45	1.463	1.19	1.97	1.99
April 28	1 07	1.145	1.29	2.23	2.27
April 29	2 26	1.308	1.05	1.93	1.97
General mean					2.167
Mean of results prior to March 26, 1903					2.229
Mean of results after March 26, 1903					2.080

general mean, the means also of observations before and after March 26, when, for some unexplained reason, a fall of about 10 per cent was noted in the computed solar constant. The observations of February 19,[5] March 25, 26, and April 29, 1903, appeared to be entitled to the greatest weight among those given, on account of the regularity of the actinometric curves of those days and the closeness with which the plotted points for determining the atmospheric transmission coefficients lie upon straight lines, as shown for two of the days in question on fig. 1.

FORM OF THE NORMAL SOLAR ENERGY SPECTRUM OUTSIDE THE EARTH'S ATMOSPHERE AND THE PROBABLE TEMPERATURE OF THE SUN.

The reader has no doubt noted that, by applying corrections for atmospheric and instrumental absorption, the bolographic spectrum energy curves may be reduced in form as well as in area to represent the distribution of energy in the spectrum of the solar beam outside the atmosphere. This has been done in several instances, and in doing so the curves have been transformed from the prismatic to the normal wave-length scale by taking account of the prismatic dispersion, and several of these curves are plotted on fig. 3 In these curves no account is taken of selective absorption bands, whether solar or terrestrial, smoothed curves only being given.

It will be noted that there is a fair agreement in general form between these independently derived curves, and that they unite in fixing the wave length of maximum energy at about 0.49 μ.[6] Their agreement would be more exact, there can be little doubt, if it were not for the large and variable absorption of the silvered surfaces in the optical apparatus for wave lengths at and beyond the region of maximum energy. The transmission of the spectroscope at a wave length of 0.45 μ has varied on this account at different times from 33 per cent to 15 per cent, whereas at wave lengths of 1 μ and thereabouts the transmission always approaches 90 per cent. The spectroscope mirrors are resilvered about once in two months and the siderostat mirrors still oftener.

Wien has derived a law connecting temperature with wave length of maximum radiation, which is expressed as follows, where T is the absolute temperature and λ_{max} the wave length of maximum intensity of radiation expressed in microns:

$$\lambda_{max}\, T = \text{constant}.$$

The value of this constant for the radiation of a "black body" or perfect radiator as determined by Paschen,[7] Lummer and Pringsheim,[8] and others is about 2900, while for bright platinum Lummer and Pringsheim give 2630 with values for other substances intermediate between these.

Taking the higher value in connection with the observed position of maximum in the solar energy curve outside the atmosphere, we find that as regards the wave length of maximum radiation the sun's radiation may be assumed comparable to the emission of a "black body" at 5920° absolute. Readers will draw their own conclusions as to the probability that the solar temperature actually lies near this value. It may be remarked that a further correction of the energy spectrum curve for the selective absorption of the solar envelope would undoubtedly reduce the wave length of maximum radiation still further, and would thus incline us to the view that the interior of the sun is at a higher temperature than the above considerations alone would indicate.

[5] February 19, 1903, was the most extraordinary day as regards absence of water vapor in the atmosphere which has ever been noted here. The great water-vapor bands ϕ ψ in the infra-red spectrum were nearly filled up, and the long wave length side of the band Ω presented an almost unrecognizable appearance.

[6] The wave length of maximum energy determined by Mr. Langley on Mount Whitney was about 0.52 μ.

[7] Paschen, Astrophysical Journal, IX, 306, 1899.

[8] Verhandlungen d. Deutschen Phys. Ges. III, 37, 1901.

TREES AS FORECASTERS OF RAIN.

By CURTIS J. LYONS, Honolulu, Hawaii, dated October 15, 1902.

With respect to the query on page 315 of the MONTHLY WEATHER REVIEW for June, 1902, as to whether leaves of trees and shrubs turn up their lower sides previous to rain, the fact is this: A steady wind does not cause the leaves to turn in this way, because the leaves adjust themselves on the twigs of the tree or shrub to the wind in that particular direction. But a sudden change in wind seems to take the leaves unawares, and they immediately show their undersides until they become accustomed to the new direction. That is exactly what takes place before a thunderstorm. A change from trade wind to southerly or westerly wind here always shows the under side of the leaves. Curiously enough a sudden gust while the writer was reading the note in the WEATHER REVIEW gave an instance of the very thing in question.

CLIMATOLOGY OF COSTA RICA.

Communicated by Mr. H. PITTIER, Director, Physical Geographic Institute.

[For tables see the last page of this REVIEW preceding the charts.]

Notes on the weather.—On the Pacific slope, the rainfall was exceptional for the season, with strong northerly winds and much dampness. In San José, pressure and humidity were normal, with a slightly lower temperature; after the 8th it rained most of the time, with a heavy and cold northeast wind. Sunshine one hundred and one hours against a normal of one hundred and fifty-eight hours. The instability of the weather delayed the coffee picking, and the strong and damp winds, quite unusual at this time of year, were very prejudicial to the public health. On the Atlantic slope the rainfall was excessive, causing everywhere inundations and landslides. The only way of communication with Port Limon, i. e., the Costa Rica Railroad, has been interrupted for a distance of 13 miles, and has suffered many other damages.

Notes on earthquakes.—December 16, 10^h 36^m a. m., slight shock NW.–SE., intensity II, duration 3 seconds. Another slight earthquake was reported from Tres Rios on the 20th.

THE POLAR AURORA OF OCTOBER 30-NOVEMBER 1, 1903.

Communicated by JAMES PAGE, United States Hydrographic Office, dated Washington, December 14, 1903.

During the night of October 30–31, and again during that of October 31–November 1, observers aboard vessels in higher latitudes report having witnessed remarkable displays of the aurora borealis or northern lights. The phenomenon was observed in both the Atlantic and Pacific oceans. (See the report of the steamship *Victoria* given below.) Its occurrence was not simultaneous throughout, different observers recording the appearance and disappearance of the lights at different instants of absolute